TRANSFORMER MODULE FOR A WELDER

The present invention relates to the art of electric arc welding and more particularly to a modular transformer operated by high frequency and having an output for welding and a module for such transformer.

INCORPORATION BY REFERENCE

The invention relates to a module that can stand alone or be combined with similar modules to form a high frequency transformer for use in electric arc welding. The actual electrical circuit for the transformer can vary; however, a representative transformer circuit is shown in Blankenship 5,351,175 incorporated by reference herein as background information. The transformer module is an assembly which forms the secondary of a transformer, wherein the primary is interleaved through one or more modules. If more than one module is used, they are used in a matrix transformer. This technology is well known and is shown in Herbert 4,942,353 which is incorporated herein so that disclosure of the matrix transformer technology need not be repeated. In Herbert 5,999,078 two adjacent magnetic cores are provided with secondary windings and primary windings wherein each module includes a half turn of the secondary winding. These modules merely provide a flat conductive strip through a core to be connected as a part of a secondary winding. The primary winding is then interleaved through the modules in accordance with standard matrix transformer technology. A similar module having several turns in a given core is shown in Herbert publication No. 2002/0075119. This patent and publication are incorporated herein to show prior art technology regarding a module used for a secondary winding in a matrix type transformer. All of these patents are included as background information.

BACKGROUND OF INVENTION

In electric arc welding it is necessary to create high currents from a power source, such as an inverter. To accomplish this objective, the inverter must be operated at a switching frequency which is quite high, such as 40 kHz so that the size of the components and the cost of the components are low. To create high currents from power sources using high switching frequencies, it is normal to merely employ an output transformer involving a primary and secondary. Consequently, the transformer has to be relatively robust in construction and capable of generating and handling high currents. Such transformers are quite expensive and bulky.

THE INVENTION

The present invention relates to electric arc welding wherein a power source is operated at high switching frequency, such as 40 kHz. In accordance with the invention, the output transformer of this electric arc welder is a coax configuration where the secondary windings of the output transformer are constructed so the primary winding can be passed through one or more module to produce a highly coupled transformer with a very compact construction and enhanced heat dissipation characteristics. The invention is directed to a novel and unique module construction allowing a single module or multiple modules to be applied to an electric arc welder. A single or multiple modules are used dependent on the power output requirements.

The module of the present invention comprises a first coaxial set of concentric, telescoped conductive tubes separated by a tubular insulator, a second coaxial set of concentric telescoped conductive tubes separated by a tubular insulator and a magnetic core around each of the tube sets so that each set of conductive tubes has an elongated central passage for accommodating at least one

primary winding. This module includes a conductor connecting the tubes of the sets into a series circuit so the output of each module is directed to a rectifier for conversion into a portion of the output current necessary for electric arc welding. The current from all of the modules are summed to obtain a welding current.

By using this unique module design, the module can be used by itself or as a plurality of modules can be interleaved with one or more primaries to create a welding current having an output capability in excess of 1000 amperes.

The primary object of the present invention is the provision of a modular transformer for an electric arc welder.

A further object of the present invention is the provision of a module, as defined above, which module involves parallel coaxial tubes connected in series and defining central passages for a primary or primaries of the output transformer of a power source used in electric arc welding.

Yet another object of the present invention is the provision of a module, as defined above, which module employs two concentric conductive tubes connected in series in a single module to define a multi-turn secondary winding for an output transformer of an electric arc welder.

A further object of the present invention is the provision of a matrix transformer at the output of a power source used in electric arc welding.

These and other objects and advantages will become apparent from the following description taken together with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a pictorial view of a module constructed in accordance with the present

invention;

FIGURE 2 is a side elevational view of the module showing in partial cross-section one side of the concentric tube construction;

FIGURE 3 is a schematic wiring diagram illustrating the current flow in a module as shown in FIGURES 1 and 2;

FIGURE 4 is a wiring diagram of the module shown in FIGURES 1-3 in conjunction with a single primary winding interleaved through the passages of the parallel concentric tube module;

FIGURE 5 is a schematic wiring diagram similar to FIGURE 3 illustrating a modified module utilizing two parallel tubes with a full wave output rectifier;

FIGURE 6 is a wiring diagram showing three modules as illustrated in FIGURES 1-3 connected as the output of the power transformer in an electric arc welder;

FIGURE 7 is a schematic wiring diagram of the high switching speed inverter used for the primary winding and/or windings that are interleaved in the modules schematically represented in FIGURE 6 and shown in detail in FIGURES 1-3 and in FIGURE 8; and,

FIGURE 8 is a pictorial view of three modules connected as shown in FIGURE 6 utilizing a plurality of modules as disclosed in FIGURES 1-3.

PREFERRED EMBODIMENT

A novel secondary module constitutes the basic building block of the present invention. The preferred embodiment is shown in FIGURES 1 and 2 wherein secondary module A is constructed to receive one or more primary windings P through a pair of parallel cylindrical openings designed

to accommodate one or more primary windings in parallel relationship. Module A is used both as a single secondary winding, or as one of several modules in a matrix transformer where primary winding P is interleaved through two or more modules A as will be explained later. In the preferred embodiment, module A is formed from a first assembly 10 with a first tube 12 terminating in a lower tab 14 having a connector hole 16. Central passage 18 in tube 12 is used as the primary winding passage when module A includes only the first assembly 10. As will be explained, the preferred embodiment has two assemblies formed by telescoping two coaxial conductive tubes usually formed from copper and telescoped around each other. Second tube 20 of first assembly 10 includes a terminal tab 22 with a lower connector hole 24 and has a central cylindrical passage 26. To fix tube 12 with respect to tube 20, so the tubes are in parallel and in spaced relationship, a first jumper strap 30 is provided. Two space holes in strap 30 surround the first end of tubes 10, 20 so weld joints 32 fix the tubes into the holes. As so far described, the jumper strap is at one end of the tubes and the tubes are parallel and spaced with the second ends having protruding tabs 16, 22, respectively. As will be explained later, only assembly 10 may be used; however, the preferred embodiment involves a coaxial relationship involving a second assembly 40 essentially the same as assembly 10 with tubes having lesser diameter so that they telescope into tubes 12, 20. Assembly 40 includes third tube 42 having a lower tab 44 with a connector hole 46 and a central passage 48 to accommodate winding P. A fourth tube 50 has a lower tab 52 with a connector hole 54 so that the third and fourth tube can be joined by a second jumper strap 60 provided with spaced openings surrounding the top or first end of tubes 42, 50. Weld joint 62 around the tubes joins the tubes into the holes of jumper strap 60. This second assembly is quite similar to the first assembly except the

diameters of tubes 42, 50 are substantially less than the diameters of tubes 12, 20. In the cylindrical gap between the tubes, a Nomex insulator sleeve or cylinder 70, 72 is provided. These cylindrical insulator sleeves electrically isolate the coaxial tubes forming the basic components of module A. Plastic end caps 80, 82 are provided with two transversely spaced recesses 84 in cap 80 and two spaced recesses 86 in cap 82. Only one of the recesses 84, 86 is illustrated in FIGURE 2. The other recesses are the same and need not be illustrated. The construction of the left coaxial assembly of module A is essentially the same as the construction of the right coaxial assembly as shown in cross-section in FIGURE 2. As illustrated, between cap recesses 84, 86 there are provided a plurality of ferrite donut-shaped rings or magnetic cores 90-98. To center the cores there are provided a number of silicon washers 100 so bolts 110 having heads 112 clamp the end caps together. This action holds the spaced rings around the coaxial tubes of module A. Assemblies 10, 40 with the coaxial tubes are held onto module A by an upper plastic nose 120 having an arcuate primary winding guide 122. The nose is held onto end plate 82 by transversely spaced bolts 124. Nose 120 includes laterally spaced slots 126, 128 so that the nose can be moved from one edge of assemblies 10, 40 to the center position by riding on spaced jumper straps 30, 60. When in the center of the module, the plastic nose is bolted to end cap 82. This clamps assemblies 10, 40 onto module A in the position shown in FIGURE 2 and holds straps 30, 60 in spaced relationship. The coaxial tubes are aligned by holes 80a, 82a concentric with cylindrical recesses 84, 86 in end caps 80, 82, respectively. Two of these holes are located in each of the end caps. Washers 100 center the coaxial tubes in the cylinder formed by core rings 90-98.

In the preferred embodiments, module A is connected as a secondary for a high frequency

transformer driven by a primary from an inverter. This electrical arrangement involves connecting assemblies 10, 40 in series by a center tap connector 130 having holes 132, 134 and 136. A rivet 140 connects hole 132 with tab 52, while rivet 142 connects hole 136 with tab 14. To stabilize center tap 130, the ends of the tap are provided with cylindrical wings 144, 146, best shown in FIGURE 2. As shown in FIGURE 3, module A is connected to rectifier 150 having diodes 152, 154 and an output terminal 156. By this arrangement, the single coaxial module allows primary winding or windings P to be leaved through cylindrical passages 48, 56 so the module is a secondary of a high frequency transformer. This is a normal use of the present invention when employed for an electric arc welder. A simplified wiring diagram of the embodiment is illustrated in FIGURE 4 to show primary winding P and secondary windings 12/20 and 42/50.

In accordance with an aspect of the invention, module A' shown in FIGURE 5 includes only tube assembly 10 with only conductive tubes 12, 20 that define terminal ends 16, 24. These terminals are connected across a full wave rectifier 160 having output terminals 162, 164. Tubes 12, 20 could be a single tube; however, in the invention two tubes are used to minimize inductance so the primary winding from the inverter is leaved around jumper 30 through center winding accommodating openings 18, 26.

A plurality of modules A are arranged to provide a high frequency transformer for a welder represented by electrode E and workpiece W in FIGURE 6. This matrix transformer concept is illustrated schematically in FIGURES 6-8 wherein modules A1, A2 and A3 are joined together by end straps 190, 192 in one end of the multiple module assembly shown in FIGURE 8 and end straps 194, 196 on the other end. Bolts clamp a frame around modules A1, A2 and A3 to assemble them

into alignment, as shown in FIGURE 8 wherein each set of passages 48, 56 is in parallel and are aligned in side-by-side relationship. The wiring diagram for the assembly shown in FIGURE 8 is illustrated in FIGURE 6 wherein terminals 156 are connected in parallel at terminal 170 and center tap 148 is connected in parallel at terminal 172. The primary windings from one or more inverters are shown schematically in the wiring diagram of FIGURE 7. Inverter 200 creates an AC current in primary P1. In a like manner, inverter 202 provides an AC current in primary P2. These two primaries are interleaved together through modules A1, A2 and A3. In practice, two primary windings are used in the matrix transformer of FIGURE 8; however, a single winding is also used in this type of matrix transformer. FIGURES 6-8 merely illustrate that the coaxial secondary transformer module A of FIGURES 1-3 can either be used as a single secondary winding or as parallel secondary windings in a matrix transformer. Other arrangements use module A as a secondary winding for a transformer between an inverter and a welding operation. The tubular, coaxial conductors disclosed in module A are sometimes replaced by an elongated ribbon helix around the center axis of the individual tubes. Such helix configuration still provides the coaxial relationship between the concentric tubes. The term "tube" defines a continuous tube conductor, as so far described, or the helix tube as used in the alternative embodiment.